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Low Cost Modular Telemetry for Coastal Time-Series Data

http://dunkle.whoi.edu/webdata/LCT-Buoy/

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ABSTRACT

The purpose of this project was to develop and demonstrate a low cost, easy to operate system for collecting and disseminating coastal ocean data. The system that was developed uses acoustic modems to transfer data from instruments on the seafloor to small surface buoys or existing navigation buoys that are equipped with acoustic receivers and RF links. Data received by the buoy's acoustic receiver are forwarded via the RF link to a station on shore. The shore station transfers the received data via landline to WHOI where it is automatically placed on a project website that is accessible to all. Key elements in this system include: 1) low cost acoustic transmitters that are deployed with each instrument, 2) small, easy to deploy surface buoys that carry the acoustic receivers and RF links, 3) a network architecture that allows a single surface buoy to receive data from a number of subsurface instruments, and 4) a back channel to the surface buoys from the laboratory at WHOI so that the acoustic receivers can be modified without requiring a visit to the site.

During the project period, two sites in Massachusetts Bay were instrumented with bottom-mounted ADCPs and associated acoustic transmitters. One site employed a small, special purpose surface buoy for the surface platform and the other used an existing Coast Guard navigation buoy to support the acoustic and RF equipment. Both buoys transmitted their data to the same shore site. The field operations proved the utility and cost effectiveness of the small surface buoy and mooring system and the RF links. The acoustic link operated reliably, but exhibited higher error rates than anticipated. As a result, funding was obtained to continue the development work beyond the original proposal period and recent field results reflect a much improved error rate. The present packet error rate for the acoustic link is 0.2% or less over periods of several months and over a full range of weather and sea conditions.

INTRODUCTION

The objective of this project was to develop a low-cost system for retrieving oceanographic data from instruments in the coastal ocean and delivering these data over the World Wide Web in near real time. The system (Fig. 1) consists of 4 components: (1) a low-cost acoustic data link from oceanographic instruments below the surface to a surface buoy; (2) an acoustic modem and integrated radio frequency link to receive the acoustic transmissions and telemeter data to shore; (3) a buoy and mooring system for deployment of the surface electronics and antennas, and (4) a system for distributing the data over the World Wide Web.

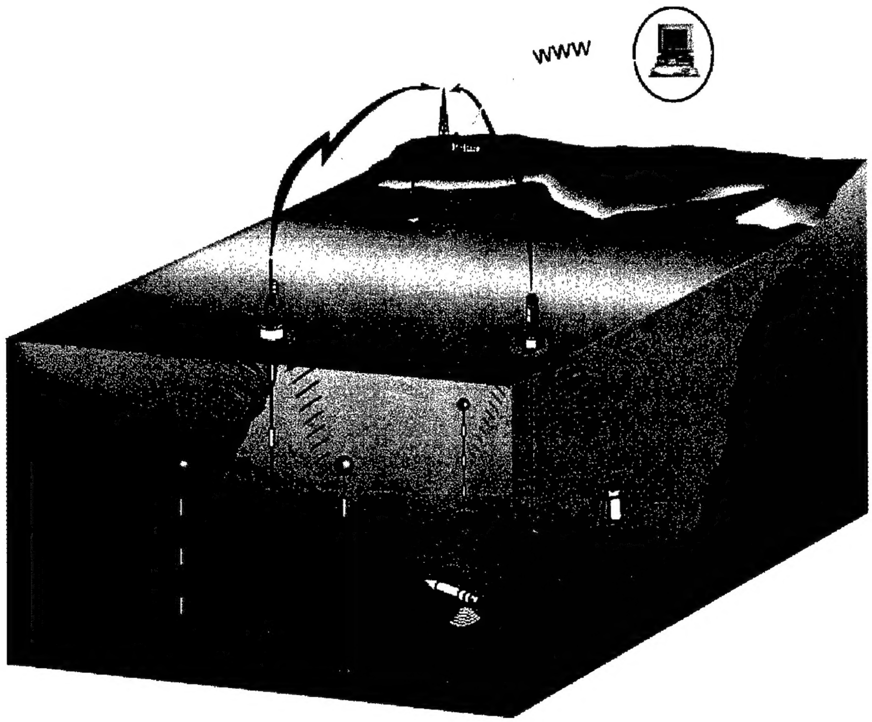

Figure 1. Concept drawing of the Portable Coastal Observatory illustrating the acoustic and RF data links from sea to shore and the final connection to the web.

The project was funded under the NOPP and was conducted cooperatively with the U.S. Geological Survey, Woods Hole Oceanographic Institution, RD Instruments, the Massachusetts Water Resources Authority, and the U.S. Coast Guard.

TECHNICAL APPROACH

The data telemetry and delivery concept that was developed can be thought of as a Portable Coastal Observatory. The approach provides a cost effective means to monitor the coastal ocean on a variety of space and time scales and distribute the data collected over the web in near real time. Low cost acoustic links are used to connect sensors to surface buoys that are equipped with radio links that transfer the data to shore. This approach avoids the need to lay fixed cables on the seabed to get real-time data and has the added feature that the sensors and RF buoys are easily moved to new locations. The receive system, located in the surface buoy, is capable of collecting and forwarding data from many independent sensors within the acoustic network. When the data is received by the radio link on shore, it is immediately forwarded to a website (http://dunkle.whoi.edu/webdata/LCT-Buoy/) that is available to the public.

RESULTS

Two sites were instrumented with ADCPs provided by RD Instruments. The ADCPs were interfaced to acoustic modems and configured to transmit hourly current profiles. Utility Acoustic Modems (UAMs), which were developed at WHOI prior to this project, were used during the field trials in place of the Low Cost Transmitters (LCTs) because the LCTs were not yet ready to be used in the field. (The LCT design has now been completed and they are being used successfully on the continuation project). A small surface

buoy and mooring was designed and two systems were fabricated for use at the Scituate site in Massachusetts Bay (Fig. 2). The surface buoy and mooring is small and easy to deploy and has proven to be quite robust. It has been deployed for about 1 1/2 years at Scituate without any mooring failures. A key feature of the mooring is that the dual acoustic receive hydrophones are suspended well below the surface, which dramatically improves the acoustic performance of the system. The dual hydrophones are used for diversity reception, which also has a significant impact on acoustic performance.

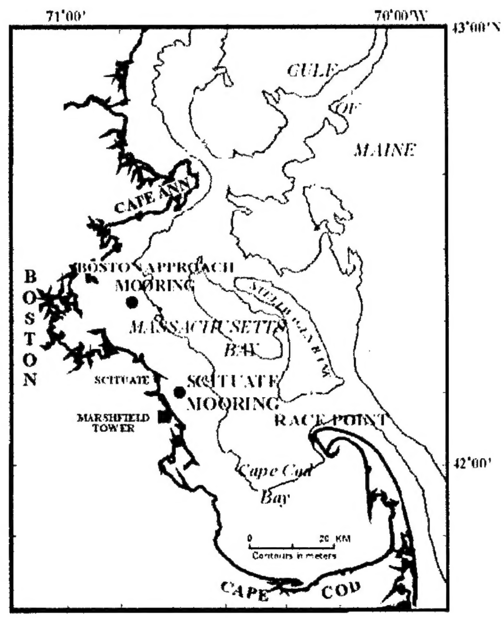

Figure 2. Location of the Scituate mooring site and the Boston B buoy site in Massachusetts Bay. The shore RF station is located at the Marshfield Tower.

Surface buoy electronics were installed on both the Scituate buoy and the Boston B Coast Guard navigation buoy. The surface package consisted of a UAM interfaced directly to a Freewave RF modem and an alkaline battery. At the Scituate site, the system worked reliably for many months, forwarding hourly ADCP profiles to shore and from there to the website. The acoustic link, however, exhibited high packet error rates (see Fig. 3) and we eventually decided to modify the frequency band and the modulation scheme that we were using. When these modifications were implemented (see period after June 2001 in Fig. 3), the acoustic performance improved substantially to about 95% error-free packets. When diversity reception was implemented (August 2001 in Fig. 3), the link performance improved further to about 99.8% good packets and has continued at this level or better to the present. (Note that a packet is 32 bytes of data). The Boston B buoy installation has not worked well due to the acoustic problems mentioned earlier, to RF implementation problems, and because the Coast Guard buoy mooring does not allow the hydrophones to be positioned deep in the water column. On the Coast Guard buoy the hydrophones are deployed at about 3 m depth in a molded hose that is hung over the side of the buoy. We are still working on the Coast Guard buoy implementation and hope to get it operating reliably this spring.

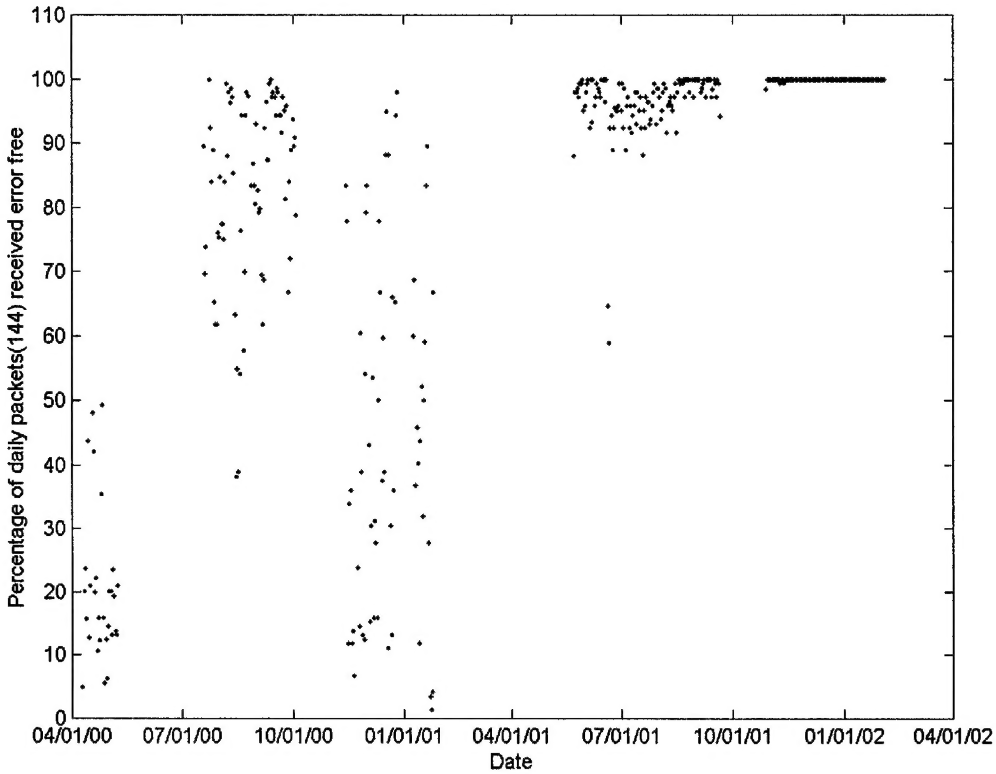

Figure 3. The percentage of packets received without errors as a function of time. One hundred and forty four packets are transmitted each day.

CONCLUSIONS

- The acoustically linked coastal telemetry concept is being demonstrated in prototype form in Massachusetts Bay. The moored surface buoy and other hardware have proven to be robust, low cost and easy to use.

- Design and construction of the low-cost acoustic transmitter (LCT) required two years, longer than expected. However, recent field tests with the new hardware and modified acoustic protocols have proven both the reliability of the hardware and the robustness of the acoustic data link. Acoustic error rates have been negligible with the modified equipment.

- The telemetry system on the stand-alone research buoy at the Scituate site has been operating reliably for many months. We plan to add a Seabird CTD to the sensor array at this site in the spring.

- The telemetry system designed for the USCG Boston Approach Buoy has not operated reliably to date. We are in the process of updating the acoustic equipment on the buoy and adding an Iridium RF link to the system to improve system performance. These modifications will be installed this spring.

- A real-time data processing and display capability has been developed and is available via the project web site, http://dunkle.whoi.edu/webdata/LCT-Buoy/. Refinements to this page are ongoing.

We have developed and demonstrated a reliable and easy to use infrastructure for a Portable Coastal Observatory. The low-cost acoustic link is working well at modest data rates (160 bps uncoded, 80 bps coded) with almost no errors. The small coastal buoy systems are reliable, easy to maintain and relatively inexpensive. The RF links are commercially available and work well in the marine environment. We are in the process of implementing an improved system on the Boston B buoy to overcome some of the problems encountered at that site. The web-based data distribution system is operational, but is being improved and made more automated as part of the project continuation. Various elements of the system are being used by other projects and other researchers because they have proven to be reliable and inexpensive. These other projects include:

1. Northern Gulf of Mexico Littoral Initiative- two acoustically linked buoy systems have been deployed in the Gulf of Mexico.

2. Short term deployments of the small coastal buoys have been made at a number of sites including Bermuda, Monterey Bay, and Hudson River estuary (planned).

3. Ultramoor- a new long term mooring design is deployed offshore Bermuda and uses the LCT designs developed for the Massachusetts Bay work.

4. A Moored Profiler with real time telemetry using an acoustic link from the profiler to a small surface buoy will be deployed offshore New England in October 2002.

PUBLICATIONS

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